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Research on the environmental performance of a natural material wooden house

Hiroto Takaguchi[a]*, Yusuke Nakajima[b], Kei Kawamura[a], Shumpei Uchida[a] , Yutaka Tonooka[c] , Akinori Sagane [d],

[a]*Waseda University, 3-4-1 okubo, shinjuku-ku, tokyo, 169-8555 Japan*
[b]*Kogakuinn University, 1-24-2 nishishinjuku, shinjuku-ku, tokyo,163-8677 Japan*
[c]*Saitama University, 225 shimookubo, sakura-ku, saitama-shi, saitama, 338-8570 Japan*
[d]*AMBIEX, 1-10-18 nakane, meguro-ku, tokyo, 152-0031 Japan*

Abstract

In this study, we examined the advantages of houses that use a lot of wood and natural materials and that also have breathable walls. There is insufficient research literature concerning the characteristics of effects obtained by using substantial quantities of wood for interiors. Typical Japanese modern houses have a damp-proof membrane but this risks being damaged during the tenure of residents or by earthquakes. Breathable walls do not have such a damp-proof membrane. We measured the environmental performance (indoor thermal environment, thermal environment and humidity in walls, and energy consumption) of four houses that use large amounts of wood, with each house using approximately 1.5 times the amount used by a typical wooden house. Results for one of these houses using large amounts of wood, even the room that was not air conditioned was most stable in terms of relative humidity, and 73.1% of measurements were classified as being within the central range of humidity. And the humility inside the wall was low enough to avoid the mold growth. From the viewpoint of energy, generally theses houses consumption of energy were smaller than the national average, but one was bigger because of the size of family and neighborhood circumstances.

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Keywords: Indoor-temperature and humidity, Measurement, Wooden-house, Natural materials ;

1. Introduction

Japan is a country with rich forest resources, with forests occupying 67% of national land in Japan [1]. However, the domestic self-sufficiency rate of wood (not for pulp) is low (41.7%) [1]. Presently, trees planted in Japan after WW2 have reached an adequate stage of maturity for felling and there is a demand

*Corresponding author. Tel.: +81-3-5286-2494; fax: +81-3-5286-8116
*E-mail address:*takaguchi@waseda.ac.jp.

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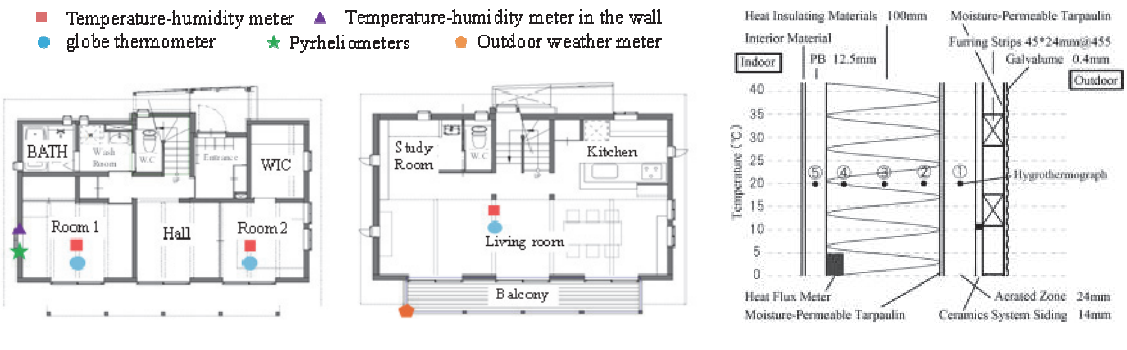
Table 1. Outline of measurements of House Y

■House Name	House Y	■Survey Period	1/1/2012-12/1/2012
■Site	Meguro-ku, Tokyo	■Survey Item	Temperature, RH (room, outside, wall)
■Method of Construction	Husband,Wife,Grandmother,Two children		Globe Temperature (room)
■Total Floor Area	99.37 (m^2)		Wind velocity, quantity of sunlight
■Floor	Two Floors + loft		Electricity consumption, gas consumption
■Heat Loss coefficient	2.17 (W/m^2・K)	■Measurement Interval	10 minutes
■Gap Equivalency Area	5.0 (cm^2/m^2)		



(a) *(b)* *(c)*

Fig. 1. (a) 1st floor measurement plan; (b) 2nd floor measurement plan; (c) measurement plan for walls

for these from both the viewpoint of forest resource management as also for CO_2 fixation. It is said that using a substantial amount of wood for detached housing is effective in order to promote utilization of domestic timber. However, there are few studies that have substantially evaluated the influence of the living environment created by using large quantities of wood for interiors.

We measured the indoor thermal environment, the thermal environment of the walls, and energy consumption of houses that use a large quantity of wood. We refer to these as, "natural materials wooden houses." In this study, we define a natural materials wooden house as a wooden house using a quantity of wood more than 1.5 times that used by the typical Japanese wooden house.

We analyzed the advantage of these houses from the viewpoint of comfort, condensation in the walls, the possibility of mold forming in the walls, and energy saving.

2. Outline of the targeted houses and measurement

We conducted measurements within four natural material wooden houses (two detached houses and two apartments) from January 1, 2012 to December 31, 2012. Each of these is located in central Tokyo in Japan. Table 1 shows the outline measurements of House Y and in this paper, we report the results of this house as a representative case. Figure 1 shows the outline of measurement points and types. We measured indoor and outdoor temperature and humidity, globe temperature, and solar radiation by pyrheliometer, in order to understand indoor comfort and related changes. We also measured the thermal environment within walls, in order to evaluate insulation performance and temperature-humidity distribution.

3. Measurement results

3.1. Indoor thermal environment

Figure 2 shows an indoor temperature-humidity air diagram plot. Room 2, which was not air-conditioned, was most stable in terms of relative humidity, and 73.1% of measurements were classified as being within the central range of humidity (40% [RH] ~ 60% [RH]). In addition, most of the plots were included within the range of comfortable levels in terms of Predicted Mean Vote (PMV) ($-1.0 \leqq PMV \leqq 1.0$); the measurement for Room 1 was 97.8%, that for Room 2 87.2% and that for the living room 91.5%,

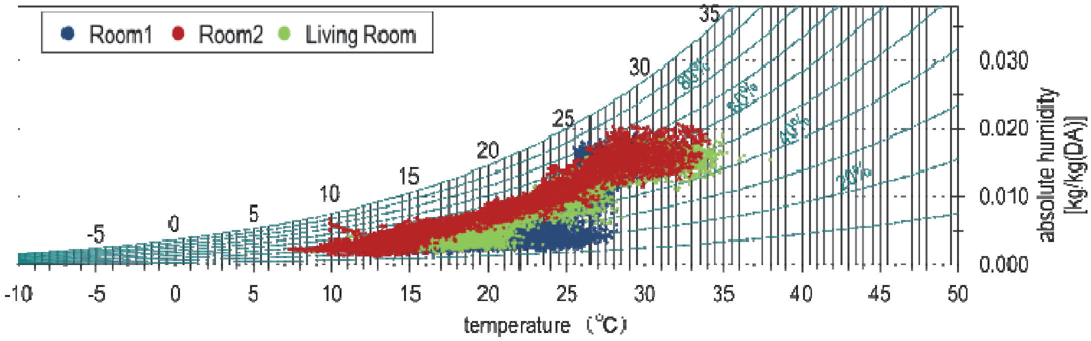
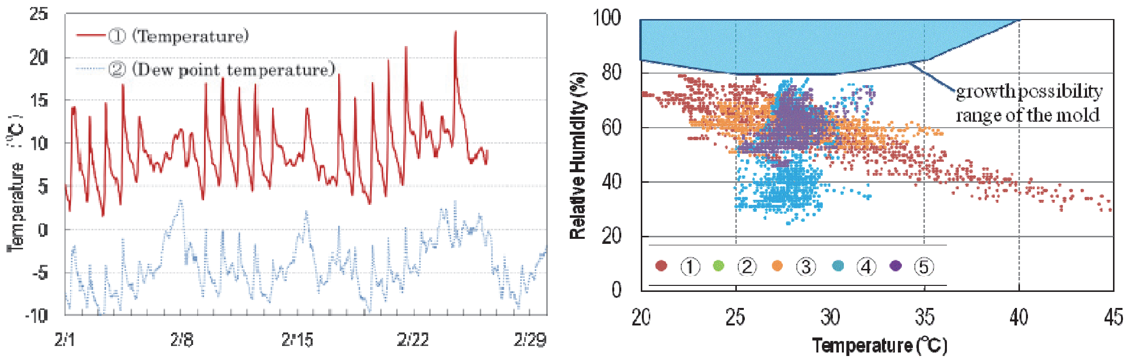
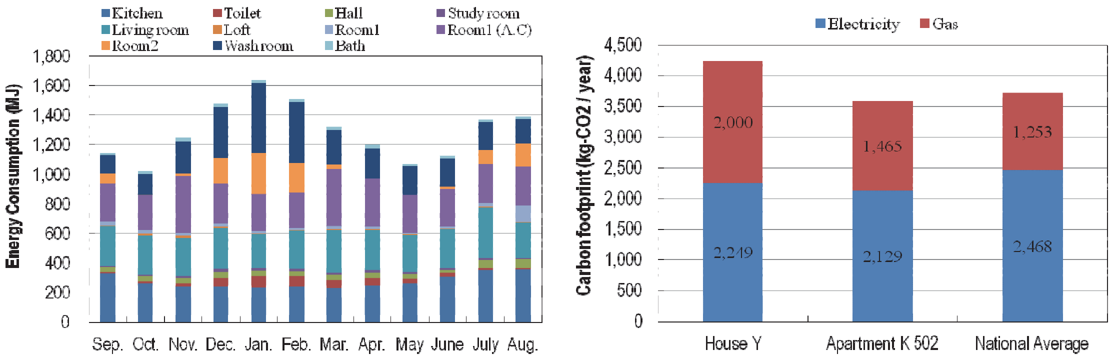


Fig. 2. Indoor temperature-humidity air diagram plot



(a) *(b)*

Fig. 3. (a) Temperature change within wall in Feb.; (b) growth possibility range of mold in wall in July



(a) *(b)*

Fig. 4. (a) Electricity consumption of House Y by month; (b) Comparison of annual carbon footprint

with data recorded in June that was between summer and winter.

3.2. Thermal environment within walls

Figure 3 (a) shows the temperature change within the wall. This indicates a small possibility of condensation occurring inside walls in winter. Figure 3 (b) shows the extremely low possibility of mold growth inside walls in July.

3.3. Energy consumption and CO_2 footprint

Figure 4 (a) shows the electricity consumption of House Y by month. Figure 4 (b) compares the annual carbon footprint of the natural materials wooden house Y, Apartment K 502 (one of the three measured houses), and the national average. The electricity consumption peak was in winter. In total, the annual carbon footprint of house Y was 528 kg-CO_2 /year more than the national average[2].

However, these reasons stem from family structure and from neighborhood issues. The family had five members, higher than average. One of these was an old woman who spent a lot of time at home. Furthermore, residents had difficulty opening living room windows because of relations with the neighborhood.

4. Conclusion

Compared with the change in outdoor air humidity, the range of change of room of these houses was stable and well controlled. This might be due to the humidity conditioning ability of wood. Condensation and mold did not occur inside the walls of House Y throughout the year, presumably by excluding humidity in the wall. As noted, this may be attributed to the humidity conditioning ability of wood, as well as to moisture permeability of thermal insulation material in House Y.

Indoor air quality results indicate that the indoor thermal environment and the thermal environment in the walls were within comfortable ranges. Humidity tended to be stable in areas of central humidity, and most of the time, within the comfortable level range of PMV. Condensation and mold did not occur within the walls of House Y.

In this paper, we could not quantitatively assess the performance of wood and energy saving trends due to social issues. Numerical simulations based on obtained measurements will therefore be used.

Acknowledge

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Biography

Hiroto Takaguchi, Dr. of Engineering, Professor of Waseda University, Faculty of Science and Engineering. Research fields are Energy Saving Technology and Equipment on Residential Building, Sustainable Process Management, Renewable energy and Materials on Building.